Effect of BladeRake Angle on Dynamics and Homogenization of Granular System in a Vertical Bladed Mixer.

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Effect of blade rake angle on dynamics and homogenization of granular system in a vertical bladed mixer

[1]T. Trávníčková, [1,2]J. Havlica, [3]M. Kohout
[1]Institute of Chemical Process Fundamentals of the CAS, v. v. i., Rozvojová 2/135, 165 02 Prague 6, Czech Republic; phone: +420 220 390 262, fax: +420 220 920 661
e-mail: travnickovat@icpf.cas.cz; [2]University of Jan Evangelista Purkinje, České mládeže 8, Ústí nad Labem, 400 96, Czech Republic; [3]Department of Chemical Engineering, University of Chemistry and Technology; Technická 5, 166 28 Prague, Czech Republic.

The granular materials are found in many areas of human exposure (food, pharmaceuticals, cosmetics, chemicals, building materials ...) and their mixing is one of the most spread industrial operations. Despite that, or perhaps because of that, granular systems appear in so many variants, there is still not a solid theoretical foundation for describing the processes taking place inside the mixing equipment. Design of industrial devices for mixing of granular systems is mostly the result of long experience or the method of trial and error. The complex dynamics of large number of particles is very difficult to monitor by using experimental methods and until recent time its description was time consuming also for mathematical simulations. With the development of computer technology, modelling of mixing granular systems using mathematical methods such as DEM (discrete element method), CFD (computational flow dynamics), or Monte Carlo method gets back to the forefront.

The mixing process was studied by using Discrete Element Method (DEM) with varying blade rake angle (30°, 45°, 60°, 75°and 90°) and blade rotational speed (from 0.1 to 960 rpm). With change of blade rake angle, the ratio between the height of the blade and bed depth changes for constant number of particles in the granular material. This ratio has a significant impact on the dynamics of the mixing process. For this reason, in addition to basic numerical experiments with constant bed depth (approximately 42 thousand particles, bed depth = 4cm), simulations were also carried out with held fixed ratio (bed depth/height of the stirrer blade = 2).

Depending on the blade rake angle and blade rotational speed the primary and secondary flows arising in a stirred granular layer, volume fraction, concentration patterns and global transport characteristics have been described. Subject of our interest is to point out the connection between the dynamics and the homogenization process that has been investigated and quantified by the Lacey mixing index (see Figure 1) for two different initial packing configurations: side-by-side and bottom-up.

In general, the side-by-side arrangement is better homogenized than axial bottom-up arrangement for all blade rakes and all blade rotational speeds. At low blade rotational speeds, the difference in homogenization by differently inclined blades is most significant. For blade rotational speed 15 RPM even agitators with 60°, 75° and 90° blade rake does not homogenize at all. The whole system rotates together with the agitator as one solid block. For higher blade rotational speed (from 150 to 960 RPM), the differences among homogenization Lacey's curves are reduced. For very high blade rotational speeds (960 RPM) the efficiency of stirring decreases and Lacey index is less than one for all blade rakes.

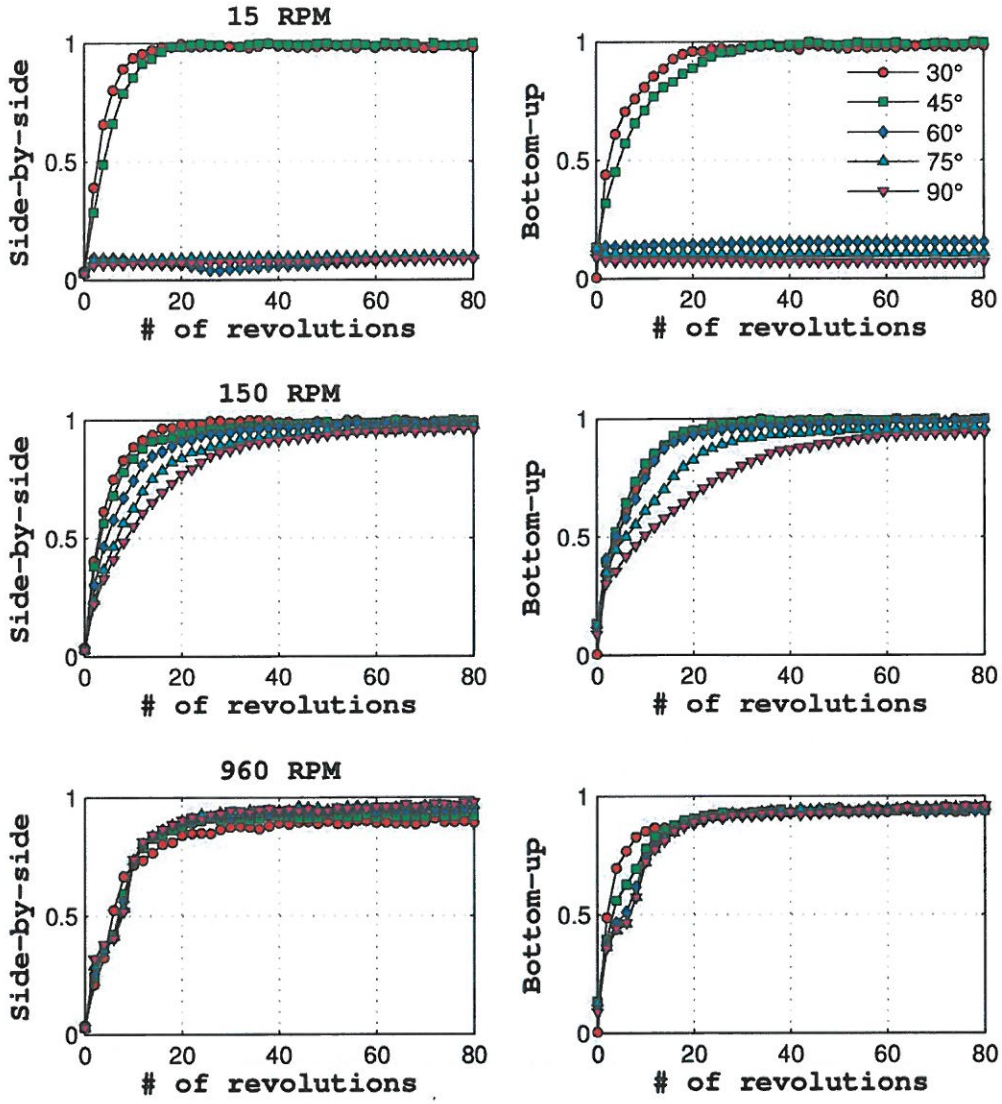

Figure 1: Lacey indexes for side-by-side and bottom-up initial packing arrangements computed for 30°, 45°, 60°, 75° and 90° blade rake and different blade rotational speeds. Fixed bed depth/height ratio of the stirrer blade used.

In our contribution we will explain the relationship between the dynamics of the mixing process and the process of homogenization. We believe that results of this comprehensive study will be helpful in optimizing the design and operation of the mixing devices.

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